REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*: 30-Aug-1999

2. REPORT TYPE: Monthly progress

3. DATES COVERED *(From - To)*: 18-06-98 to 17-07--99

4. TITLE AND SUBTITLE: Monthly Progress Report Number 8

5a. CONTRACT NUMBER:

5b. GRANT NUMBER: N00014-99-1-0158

5c. PROGRAM ELEMENT NUMBER:

6. AUTHOR(S):

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5d. PROJECT NUMBER:

5e. TASK NUMBER: Data item #0034

5f. WORK UNIT NUMBER:

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES):
Virginia Polytechnic Institue and State University,
Blacksburg, VA 24061

8. PERFORMING ORGANIZATION REPORT NUMBER:

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES):
ONR, 800 North Quincy Street, Arlington, VA 22217-5660

10. SPONSOR/MONITOR'S ACRONYM(S): ONR 311

11. SPONSORING/MONITORING AGENCY REPORT NUMBER:

12. DISTRIBUTION AVAILABILITY STATEMENT:
APPROVED FOR PUBLIC RELEASE

13. SUPPLEMENTARY NOTES:

14. ABSTRACT:

Progress report for the NAVCIITI Program for the 8th monthly period of the grant.

19990903 151

15. SUBJECT TERMS:

16. SECURITY CLASSIFICATION OF: a. REPORT	b. ABSTRACT	c. THIS PAGE	17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
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Standard Form 298 (Rev. 8-98)
Prescribed by ANSI-Std Z39-18

Navy Collaborative Integrated Information Technology Initiative

(NAVCIITI)

ONR Grant N00014-99-1-0158

Monthly Report No. 8

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18 June 1999---17 July 1999

Navy Collaborative Integrated Information Technology Initiative (NAVCIITI)

This is the eighth monthly report of the NAVCIITI program, that covers the period 18 June 1999 through 17 July 1999.

1. Introduction

The long-term objective of this program is to provide strong, integrated research capabilities in broad user communications testbeds, systems engineering, fiber optic sensors and transmission devices, secure and reliable wireless communications, effective user-friendly human computer interfaces, and scientific visualization to the Navy community. This initiative will improve the Navy's capabilities to support distributed computing, integrated services training, education, information dissemination, and simulation.

The anticipated multiyear program will establish a Navy Collaborative Integrated Information Technology Initiative (NAVCIITI, pronounced "NAV city") by creating an Advanced Communication and Information Technology Center (ACITC), on campus at Virginia Tech, integrating the efforts of more than 60 investigators currently under contract to the Navy by providing equipment and facilities for their effort, and using the collective capabilities of NAVCIITI to support Navy initiatives in distributed computing, integrated services training, education, information dissemination, and simulation, especially for purposes of network-centric battle management, managing and maintaining C4ISR attributes, and enhancement of the Naval intranet. The scope of the proposed program was developed as a result of discussions, and briefings with a group of Navy unit leaders.

2.0 Technical Summary

The program has now completed eight months. Major enabling equipment purchases have been made, as outlined briefly in our fourth monthly report, and as updated in the sixth monthly report. We have now made significant research progress using this new equipment and related facilities on campus. Progress in specific areas is discussed in the following sections.

2.1 Communications Testbeds (Jeff Reed, Charles Bostian, Brian Boyle--Task 1.2.1)

1. Progress in July

We completed the implementation of our single user adaptive receiver into reconfigurable hardware. We then tested the receiver over an IF connection. We have also integrated the basic VHDL models (which were used to implement the receiver in reconfigurable hardware) into SPW simulations. The team is now focusing on the development of more complex receiver architectures.

We are also focusing on the design of a advanced synchronization/tracking schemes for hostile environments. The scheme that we are currently investigating employs an increased length adaptive filter. We simulated the scheme for different SNR and multiple access interference conditions. Simulations show that it has superior performance,

relative to conventional peak detectors, under multiple access interference environments. It performs marginally better in single user environments.

2. Plans for August

Other plans include the integration of the RF front end into the single user receiver. The RF front end is the Miniature Radio Code (MRC), which was developed by Rockwell Collins. Delivery of the MRC is scheduled for mid-August.

3. Noteworthy Accomplishments

- Hardware synthesis of single user adaptive receiver.
- Implementation of single user adaptive receiver functions into SPW
- Design of advanced synchronization schemes that support video communication

2.2 Fiber Optic Sensors and Transmission Devices (R.O. Claus, Carvel E. Holton—Task 1.4b.3)

1.0 Introduction

The purpose of this program task is to design, synthesize and test multifunctional optical displays that are capable of presenting two-dimensional visual information while also sensing physical pressure or light pointer signal inputs.

Work performed during the prior month has concentrated on the development of self-assembled piezoelectric and electrostrictive materials.

2.0 Bending Deformation of Self-Assembled Thin Films

The bending deformation property of the ESA-synthesized self-assembled films was confirmed by initial experiments. Figure 2-1 shows a basic schematic of the bending deformation of the films. The mechanical deflection of the films can be determined by measuring the change in the position of the reflected light beam when a voltage is applied to electrodes, which are formed as shown on the thin film surfaces. Figure 2-2 shows this deflection displacement versus the applied voltage for one of the self-assembled film samples. As can be seen from Figure
2-1 and Figure 2-2, the self-assembled films have potential applications as simple actuators on flexible substrates.

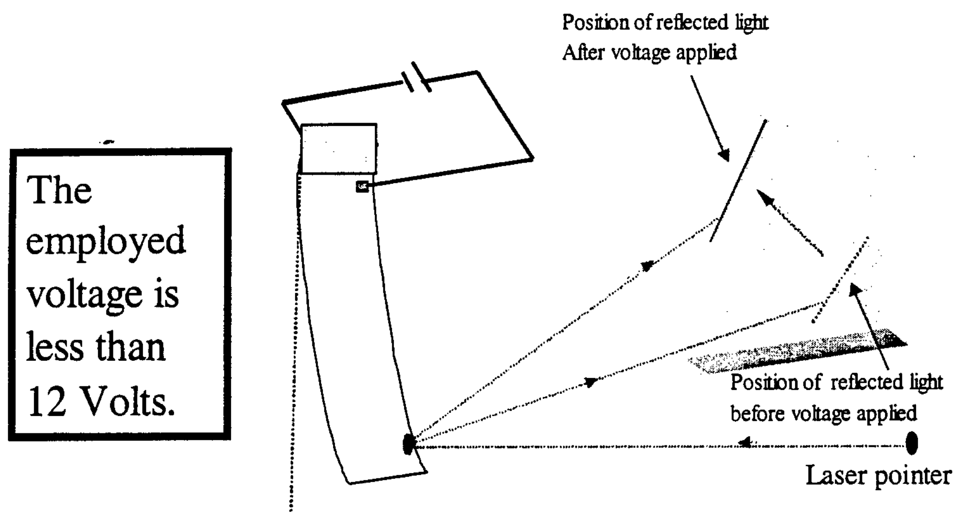


Figure 2-1. Schematic of the Bending Deformation of the Self-Assembled Films.

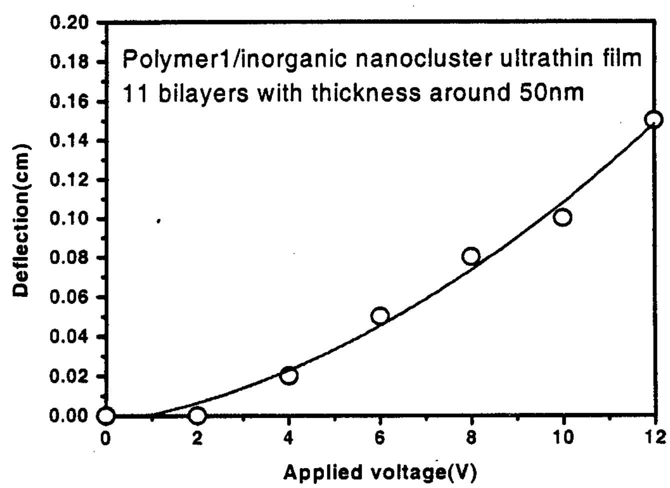


Figure 2-2. Displacement of Self-Assembled Ultrathin Films Versus Applied Voltage.

2.1 Measurement of the Piezoelectric Coefficient d_{33} of ESA Processed Films

The piezoelectric coefficients d_{33} of ESA thin films synthesized on ITO-coated glass substrates were measured by the normal load method. Figure 2-3 is a basic schematic of the setup used for this experiment.

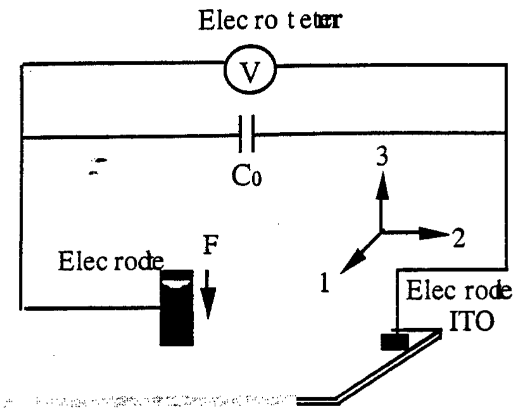


Figure 2-3. Schematic of Setup for the Normal Load Method for Measuring the Piezoelectric Coefficient d_{33} of ESA Films.

Cylindrical metal electrodes were used directly for two functions, namely, both as the load and as one of the electrodes. Standard PVDF film was employed as a reference. The d_{33} of PVDF measured with the setup shown in Figure 2-3 was 34.6 pC/N. This represents approximately a 20% measurement error in comparison to standard d_{33} data for PVDF (approximately 30 pC/N). The d_{33} piezoelectric response of the self-assembled Polymer1/PDDA film with a thickness of 65 nm, representing 50 bilayers of polymer 1 and PDDA, is shown in Figure 2-4. The thickness of the thin film was determined by depositing an

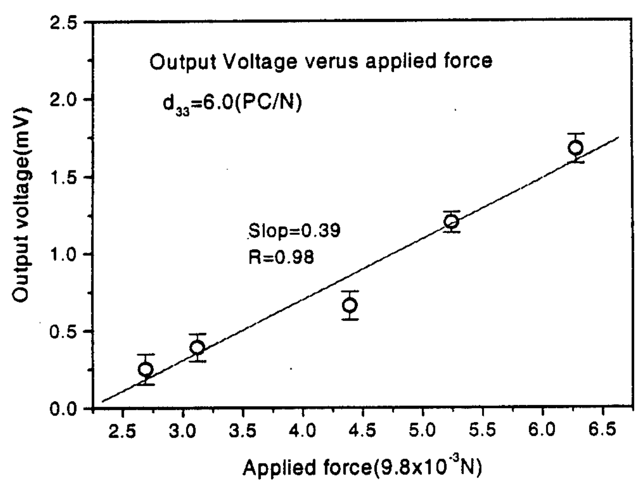


Figure 2-4. Output Voltage Generated by the Direct Piezoelectric Effect in the Self-Assembled Polymer 1/PDDA Thin Film as a Function of Applied Force (C_0=150pF).

identical ESA polymer1/PDDA thin film on a silicon p-111 substrate, and measured the thickness using an ellipsometer (AutoEL II-3W, Rudolph Technologies).

As can be seen from Figure 2-4, there is a linear relationship between the output voltage of the self-assembled polymer1/PDDA film and the corresponding applied force. This phenomenon demonstrates that the self-assembled ultrathin polymer1/PDDA film exhibits piezoelectric behavior. The experimental measurements were carried out under quasistatic conditions. The piezoelectric coefficient d_{33} measured by the normal load method can be calculated from Equation (1) as

$$d_{33}\,(dp)=D_3/T_3=Q/F=C_0V/F, \tag{1}$$

where D_3 is the electric displacement, T_3 the stress in the "3" direction, Q is the induced charge in the film within the electrode area under the applied force F, and C_0 is the capacitance of the standard capacitor used in the setup shown in Figure 2-3.

According to these results, the layer-by-layer 65nm-thick polymer1/PDDA film demonstrates a d_{33}=6.0 pC/N response. It should be noted that this response occurs without the use of electric field poling, such is conventionally used to process piezoelectric polymer materials.

Table 2-2 summarizes the d_{33} results obtained for other self-assembled films that we have investigated. Numbered polymers have been designed and synthesized in our laboratory.

Table 2-2. Piezoelectric Coefficients d_{33} of Self-Assembled Ultrathin Composite Films.

Composite films	Number of Assembled bilayers	Thickness (nm)	d_{33} (pC/N)
polymer 1/nanocluster 2	30	86	10.8
Polymer2/PDDA	50	165	83.6 (dry) 990.81 (wet)
Polymer 2/ nanocluster 1	40	206	35.3 (dry) 794.6 (wet)
polymer 3/PDDA	100	199.8	6.3
polymer 4/PDDA	50	96	152.6 (dry) 598.4 (wet)

During future program months, we will investigate and confirm this data, and study how we may integrate such materials as sensor elements into the optical display devices.

2.3 Human Computer Interface (Deborah Hix and John Carroll—Tasks 1.4.1, 1.4b.1, 1.6.1)

1. Progress during the month of July

The FakeSpace Immersive Workbench (IWB) funded by NAVCIITI monies was successfully installed during the last two days of June, and July has been spent getting the system running and preparing for research. The "Dragon" software developed at the Naval Research Lab in

Washington DC has been revised to make it run more effectively on the IWB. As mentioned in previous status reports for this grant, this software is the basis for the long-term collaboration between Dr. Deborah Hix at Virginia Tech and Dr. Larry Rosenblum and Dr. Ed Swan in the VR Lab at NRL. This collaboration is funded by Dr. Helen Gigley of ONR. We also are working to make the Dragon software interact with a specially developed input "wand" for navigation through the battlefield space. Mr. Eric Nash, the GRA funded on this project, spent several days with Dr. Swan at NRL, finalizing details for an empirical study of navigation in virtual environments.

The Center for Human-Computer Interaction has two areas of responsibility in the NAVCIITI program: The first area is in design rationale, an intersection between human-computer interaction (HCI) and software engineering. We are investigating the proactive use of design rationale in software development, specifically focusing on the management of usability rationale in a scenario-based design process through use of claims analysis, and including refinement and dissemination of such methods for analyzing usability and domain object tradeoffs in Naval software designs, prototypes, and systems. Our task in this area is to prepare a textbook for the methodology, and try to identify appropriate Naval points of contact to determine whether this methodology can be adapted to support Naval software and system development.

The second area of responsibility for the Center for Human-Computer Interaction is in computer-supported collaborative work (CSCW). We are investigating the development and application of collaborative multimedia conferencing software for education and other groupwork activities, and focuses on extensions of our virtual school software framework integrating shared notebook, whiteboard, chat, visualizations, simulations, video conferencing, etc. We will try to identify appropriate Naval points of contact to determine whether this technology can be adapted to support shipboard education and network centric warfare.

We have continued to make good progress on our technical tasks. An upper level textbook on the management of usability rationale in a scenario-based design process through use of claims analysis is complete. A contract was signed with MIT Press, and the manuscript was delivered on August 23.

We have begun work on a lower-level textbook this summer, which presents scenario-based system development as part of the undergraduate computer science curriculum in software engineering and human-computer interaction. Addison-Wesley, Morgan-Kaufman, MIT Press, John Wiley and Lawrence Erlbaum Associates have expressed interested in publishing this text, based on reviews of a chapter-by-chapter outline. Chapters 1-4 are now complete, and are being used in as text materials in CS3724 "Introduction to Human-Computer Interaction" this semester. Fourteen chapters are planned. Based on this material, we also proposed a full-day tutorial on scenario-based design for the 2000, ACM CHI Conference.

We have also made progress on several fronts in developing a system to support collaborative learning and planning interactions. We are focusing on developing and

evaluating the Virtual School, a Java-based networked learning environment, emphasizing support for the coordination of synchronous and asynchronous collaboration. The Virtual School integrates communication tools such as video conferencing, shared whiteboards, chat, and email. It also includes a shared notebook that supports collaborative planning, note taking, experimentation, data analysis, and report writing. Currently we are developing several new collaborative page types for the shared notebook, investigating off-the-shelf component reuse, experimenting with a set of synchronous and asynchronous awareness tools, and developing a comprehensive evaluation methodology to assess the usability and usefulness of such environments.

One focus of this work in the past six months has been the development of a multi-faceted evaluation methodology for complex, distributed groupware activities. We are continuing to develop methods of large-scale usage data collection over the Internet. Evaluating distributed systems call for innovative methods that do not require an evaluator to be physically present at the user's work site. We are continuing to refine our tool set composed of three interrelated processes: (1) event capturing, (2) activity filters, and (3) integrated event scripts (collated activities from multiple data across a range of contexts). This form of data logging provides multiple representations of user and system behavior that translates measures of performance into more meaningful characterizations of human-computer interaction.

2. Plans for the month of August

During August, we will continue with installing the wand mentioned above, and Mr. Nash will again travel to NRL to continue work on the empirical study of navigation.

We have begun to interview potential clients and users of our alternative environment for place-based synchronous groupwork. This information is being used as an initial user profile, requirements analysis, and task analysis.

A second focus has been the development of an alternative environment for place-based synchronous groupwork. The new environment is based on the same collaborative infrastructure as the Virtual School, and supports end-user construction of hierarchies of shared spaces. Persistent shared objects can be created within and moved between these spaces. Users can navigate from place to place using a map-based interface and can interact synchronously via text chat, whiteboards, and slide shows. They can interact asynchronously by creating and manipulating persistent objects, including message boards, shared notebooks, and Java applets. We are exploring the extent to which this interactive Java-based environment can be made more widely accessible and provide richer interactions than traditional place-based tools such as purely text-based multi-user domains (MUDs).

Publications currently submitted and in review

Carroll, J.M. & Rosson, M.B. Scenario-Based Usability Engineering. Tutorial proposal submitted to ACM CHI'00.

Chin, G. & Carroll, J.M. 1998. Articulating collaboration in a learning environment. Submitted to *Behaviour and Information Technology.*

Go, K. & Carroll, J.M. 1998. Blind men and an elephant: Views of scenario-based system design. Submitted to *ACM interactions*

Helms, J., Neale, D.C. & Carroll, J.M. Data logging: higher-level capture and multi-level abstraction of user activities. Submitted to *Annual Conference of the Human Factors and Ergonomics Society.*

Isenhour, P., Rosson, M.B. & Carroll, J.M. Supporting asynchronous collaboration and late joining in Java groupware. Submitted to *Interacting with Computers*, Special Issue on Web Software.

Neale, D.C., Dunlap, D.R., Isenhour, P. & Carroll, J.M. Collaborative critical incident development. Submitted to *Annual Conference of the Human Factors and Ergonomics Society.*

Submissions accepted for publication since last report

Carroll, J.M. *HCI in the New Millennium.* Edited book to be published by Addison-Wesley/ACM Books, contract signed in August.

Gibson, S., Neale, D.C., Van Metre, C.A. & Carroll, J.M. Mentoring in a school environment. Accepted for publication/presentation *Third Conference on Computer-Supported Cooperative Learning.*

Neale, D.C. & Carroll, J.M. Multi-faceted evaluation for complex, distributed activities. Accepted for publication/presentation *Third Conference on Computer-Supported Cooperative Learning.*

August 1999 presentations

Alpert, S.R., Singley, M.K., & Carroll, J.M. (1999). Multiple Instructional Agents in an Intelligent Tutoring System, International Workshop on Instructional Uses of Animated and Personified Agents. Stanford, CA, August, 1999.

Carroll, J.M. Scenario-based design: What, Why & How. NASA Engineering Training (NET): System Design 2. Hagerstown, MD, August 3, 1999.

2.4 Scientific Visualization (Ronald Kriz—Tasks 1.1.2, 1.4b.2, 1.6.2)

1. Progress during the month of July

We have continued to develop collaborative awareness tools for the Collaborative CAVE Console (CCC). Specifically we have added, "Record to a File" and "Playback Recorded File" features to CCC and to the voice recognition system.

Problems remain when running CCC in the CAVE on multiple CPUs that result in unpredictable core dumps. We have encountered this problem before and are confident that it can be fixed in the near future.

The Tactical interface based on HCI principles has been delayed because of problems in communicating with NRL collaborators to develop the ideas.

During July, Lance Arsenault, John Kelso, and Ron Kriz attended Multigen Paradigm training classes July 12 through 16.

2. Plans for the month of August

Efforts will focus on resolving the operational problems with the Collaborative CAVE Console.

2.5 Systems Engineering (Richard Nance, Ken Reifsnider, Ali Nayfeh—Tasks 1.3.1, 1.4a.1, 1.4a.2)

1. Progress during the month of July

Progress on the task includes the following:

1. A consortium of users for an existing engineering code developed by the investigator has been constructed. It includes Pratt & Whitney, Owens Corning, United Technologies, Allied Signal Composites, Oak Ridge National Laboratory, Goodyear, Johnson and Johnson, Westinghouse, and Allison.
2. Methodologies for information exchange and collaboration in that consortium have been constructed and are being evaluated. A recent evaluation of the "virtual school" software being developed in part by another NAVCIITI investigator suggests that the next phase of the present effort should concentrate on constructing the hardware link to a select sub-group of the consortium members for trial of the hardware and software needed to conduct these trials.
3. A consortium member from Germany (University of Kaiserslautern) is being added to the consortium, to add the element of international information exchange to the methodology. The PI on this task visited that laboratory on June 5, 1999 to construct the details of their involvement. A proposal for auxiliary funding to support the efforts of that laboratory in the conduct of their part of this task has been submitted to the **NSF.** Interaction (exchange of personnel) of the two laboratories is underway.
4. The description for the staff position to support this task has been approved by the University. A prospective candidate for that position has been hired, and begins work on 1 September, 1999.

Discussions and meetings were conducted with David Marlow and Dennis Warne of NSWCDD. The former is discussing the 6.1 issues that are needed in his planned project in Virtual Operations Network and Information Technology Interoperability. The intent is for the SRC effort to support that project. Discussions with Dennis Warne involve the efforts in developing an integrated distributed operating environment for testing and demonstrating the needed integration of data and communications required for DII-COE compliance.

2. Plans for the month of August

We have visited the NSWC Carderock to discuss interaction and implementation of some of the NAVCIITI results. Efforts are underway to construct an MOU to effect such implementations. Several target programs for implementation have been identified. We have also had discussions with Newport News Shipbuilding and Martin Marietta with the intent of bringing NAVCIITI results to the CVN77 carrier program.

2.6 Wireless Communications (Warren Stutzman, Clark Gaylord—Tasks 1.2.2, 1.5.1)

1. Progress for July 1999

We examined the input impedance of Foursquare antennas in an array environment. Simulations showed that bandwidth is actually increased over single isolated element performance. The bandwidth increased from 45 % to 73 %. This makes the Foursquare antenna very valuable as an element in a phased array. An additional feature of the Foursquare is its small electrical size (0.27 wavelength at the low end of the frequency band), permitting tight inter-element spaced in phased arrays.

We investigated the use of calculated mutual impedance values for evaluation of impedance performance during phase scanning. The technique was shown to be accurate. This approach greatly simplifies array analysis.

2. Plans for August

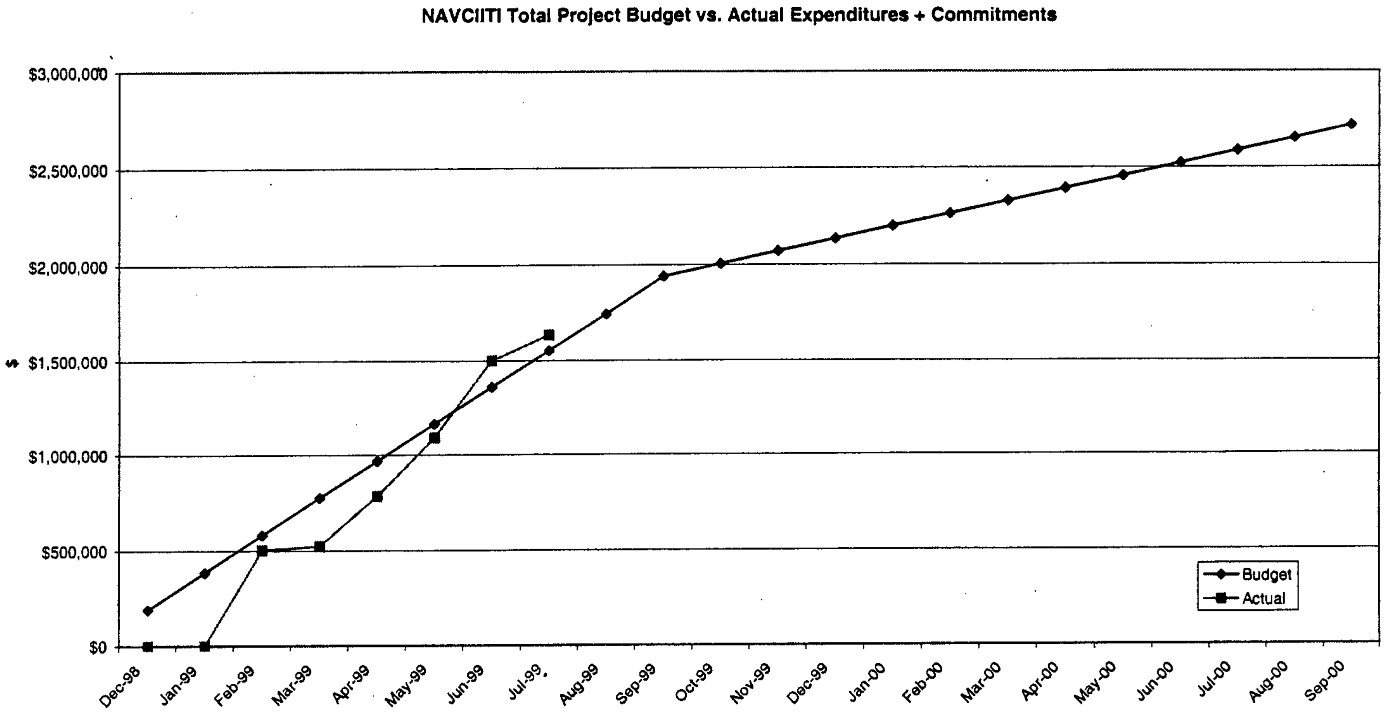
Further simulations will be performed on dual band Foursquare elements with a goal of optimized performance.

3. Accomplishments

The following paper was presented

C. Buxton, W. Stutzman, J. Nealy, "Implementation of the Foursquare antenna in broadband arrays," URSI National Radio Science Meeting (Orlando, FL), July 1999.

3.0 Financial Status



The expenditures and commitments through the month of July are noted on the graph above. We are on target to complete equipment purchases by September 30.